F-15B Flight Research Testbed Experimenter's Checklist

National Aeronautics and Space Administration
Dryden Flight Research Center
Edwards, California

Last Revision: June 12, 2000

Introduction

The F-15B Flight Research Testbed Experimenter's Checklist presents information to aid an experimenter in performing flight research on NASA's F-15B Flight Research Testbed. Information is provided in the areas of flight planning, experiment structural design and instrumentation, flight qualification, control room and data preparation, hazards and flight safety issues, procedures, the flight approval process, and general documentation. The information contained in this checklist represents general guidance that may not be applicable to all flight experiments. More detailed guidance can be obtained in specific Dryden Management System (DMS) procedures. Dryden personnel are encouraged to refer to the DMS and Dryden ISO-9000 Document Library for the most recent document version (http://xnet.dfrc.nasa.gov). The F-15B Project will work with each experimenter to determine any special requirements or deviations from the guidance provided in this checklist. An electronic version of this checklist and other project information such as detailed descriptions of the aircraft and flight test fixtures can be found on the F-15B home page at http://www.dfrc.nasa.gov/Projects/f15b-ftf.

Experimenter's Checklist to Flight

The typical tasks that must be completed by an experimenter for successful flight test on the F-15B are listed below as an informal checklist. This checklist is in the approximate chronological order for a typical experiment. Each flight test experiment is unique and different, so there may be deletions / additions of tasks; these changes should be coordinated with F-15B Project personnel.

Flight Planning:
Write Objectives and Requirements Document (ORD)
Develop Schedule and Milestones

Experiment Structural Design:
Complete Structural Design

Experiment Instrumentation and Measurement Design:
Complete Experiment Instrumentation and Measurement Design

Flight Qualification:
Flight Qualification Ground Testing (Loads Test, Ground Vibration Test, Environmental Test)

Hazards / Flight Safety:
Write Hazard Reports and submit for Project review
Provide input to Go / No-Go Instrumentation List, Mission Rules, and Operating Limitations

Control Room / Data Preparation:
Develop displays with Test Information Engineer (TIE)
Develop required data analysis tools

Procedures:
Write Test Procedures (Combined Systems Test, pre-flight and post-flight, flight test procedures)
Write Final Flight Test Plan

Flight Approval:
Create Tech Brief charts and participate in Tech Brief presentation
Participate in Flight Readiness Review (FRR) and Airworthiness and Flight Safety Review Board (AFSRB), as required

Documentation:
Write Flight Test Report
Write Flight Test Summary
Write technical report (as appropriate)

Flight Planning

Objectives and Requirements Document (ORD)

All F-15B Research Test Bed experiments require an Objectives and Requirements Document (ORD) that is generated by the experimenter, or customer. The ORD is the key document in defining specific objectives and requirements of the flight experiment. Generally, a draft ORD is generated during the formulation phase of an experiment and reviewed by the project. An approved ORD should be completed and approved by the project prior to final design and fabrication of an experiment. Project personnel can provide DFRC DCP-P-006 for a detailed flowchart of this process.

An example outline of an ORD is shown below to provide a general format that should be followed. The general format should be considered as a guide that can be customized and tailored for each flight experiment as required. The length of an ORD (may range from 5 to 30 pages) is not important as long as all of the specific objectives and requirements of the flight experiment are clearly documented prior to implementation by the F-15B project. A significant portion of the information outlined in the Experimenter's Checklist is documented in the ORD.

<u>ORD (example outline only)</u>

Schedule and Milestones

The overall F-15B flight test schedule and project milestones are developed by the F-15B Project Manager. Each experimenter will be required to generate a detailed schedule for their experiment. Detailed experiment schedules are then merged into the overall F-15B flight test schedule.

Experiment Structural Design

Structural Design Guidelines

General guidelines for the structural design of flight experiments are given below, although details of the specific structural design should be reviewed and approved by the F-15B project prior to fabrication.

In general, all experiment primary structure must be designed with the following Factor of Safety, (FS) as appropriate. Although the Flight Test Fixture (FTF) and most other experimental structures are considered secondary structure, these FS guidelines should be considered appropriate for all experiments whenever possible.

1. 2.25 FS, if structural design is verified by analysis only.

2. 1.5 FS, if proof testing is to be performed to ultimate loads.

3. If proof testing to other than ultimate loads is to be completed, a Factor of Safety between 1.5 and 2.25 may be used, as agreed upon with NASA.

Aerodynamic, inertial, thermal, and dynamic loads should be considered in the design of any experimental structure. Appropriate load combinations should also be considered.

Experiment Instrumentation and Measurement Design

Complete Experiment Instrumentation and Measurement Design

In the early phases of the design process, the experimenter should work closely with the F-15B instrumentation engineer. The experimenter should be prepared to provide rough estimates of the following:

1. Specifications of suggested electronic equipment to be integrated into aircraft and/or flight test fixture

2. Measurement requirements including required frequency response, measurement range, resolution, and accuracy

3. Proposed sensors to obtain measurement requirements

4. Proposed experiment controls - experimenter should consider how experiment should be safely controlled from cockpit during flight operations. Also, consider any special controls for ground operations and checkout.

With these requirements, the instrumentation engineer will provide information about the current instrumentation and sensors implemented on the aircraft, provide feedback on suitability of proposed equipment and sensors, and suggest strategies for implementation and integration. Based on these requirements and discussions, the experimenter should then be ready to write the Experiment Configuration and Instrumentation sections of the ORD.

Some level of measurement uncertainty analysis is suggested. This is probably best performed after measurement requirements and sensor selection has been completed. This analysis helps assure sensors, measurement ranges, and data acquisition systems are matched, sized and implemented appropriately.

Flight Qualification

Flight Qualification Ground Testing

In general, environmental testing is mandatory for electronic hardware for flight qualification. Flight qualification ground testing of structural hardware may be required depending on the structural design approach.

All experiments to be flown on-board the F-15B or the FTF will be inspected to ensure that the equipment and hardware meet standard aircraft standards. All hardware, software, and equipment submitted for evaluation should be properly prepared and should represent actual configuration and functional characteristics intended for use. Hardware is expected to be AN, MS or NAS quality. Construction (soldering, welding, wiring, etc.) is expected to meet standard aircraft practices for quality. Equipment should be ruggedized for flight conditions.

Loads Test

Loads (proof) testing may be required depending on the structural design criteria as previously discussed. The loads testing may be completed at Dryden or at the experimenter's facilities. A loads and stress report should be delivered to the F-15B Project for review.

Ground Vibration Test (GVT)

GVT of the experiment hardware may be required pending an assessment by Dryden personnel. The GVT typically involves a "hammer test" of the experiment hardware to identify the structural dynamic natural frequencies. A GVT of the final flight configuration will be performed by Dryden personnel, if needed.

Environmental Test

All flight experiments must undergo environmental testing to ensure no problems are experienced due to altitude, temperature or vibration considerations. The experiments are typically operated during environmental testing. The limits of the environmental tests are determined by the flight profile of the experiment and its mounting location.

Environmental testing is comprised of altitude testing and vibration testing of the complete, integrated hardware system or independent experiment components.

For the altitude testing, the system operation must be verified at the highest desired test altitude (pressure and temperature). In general, to provide a safety margin, the system should be tested to conditions equivalent to 5,000 feet above this highest desired flight test altitude. As a minimum, vibration testing of the system should be performed to Dryden Process Specification 21-2 random vibration curve A (8.0 GRMS). Normal system operation should be verified prior to and after completion of the vibration test.

Environmental testing may be completed at Dryden or at the experimenter's facilities. If the testing is not performed at Dryden, a test report should be delivered to the F-15B Project for review.

Hazards / Flight Safety

Hazard Reports

The experimenters are expected to provide Preliminary Hazard Reports to the project for the equipment and testing associated with their experiment. All known or suspected anomalies, deficiencies, or areas of concern should be identified. The list must be all-inclusive for any item that could fail, the risk involved if that failure occurred, and what is done to mitigate or reduce the chance of failure. Experimenters should attempt to reduce severity and risk of any hazard through the following techniques, or combination of techniques, in the following order of precedence:

1) Design to eliminate hazard or hazardous operation
2) Protective design features or devices
3) Detection or warning devices
4) Procedures, training, or protective equipment

Preliminary Hazard Reports should be developed for flight and ground hazards associated with an experiment. A Hazard Report example has been provided below as a general guide.

Hazard Report (example only)

Project: F-15B with Supersonic Natural Laminar Flow Fin
HR#: SSNLF-04
Hazard Title: Structural/Component Failure of SS-NLF Blade

Final Classification: 1-E

Hazard Background:
This hazard was added due to the possibility of structural failure of the SS-NLF Blade, the strongback or the Splitter Plate/Root Fairing.

Hazard Cause:
Severe loading conditions causing structural failure of the SS-NLF Blade or failure to the Splitter Plate/Root Fairing.

Hazard Effects:
Damage or loss of the SS-NLF Blade and/or Splitter Plate/Root Fairing, structural damage or loss of aircraft and/or life.

Required Risk Reduction Action:
The SS-NLF Blade was designed using a 2.25 factor of safety to ensure that the blade would not fail structurally. Static loads were analyzed in the "SS-NLF Test Article Stress Report" written by the XYZ Corporation. Code RS reviewed the analysis and reported that XYZ did a thorough job of analyzing the loads and designing the Blade and supporting structure. Code

RS personnel performed the dynamic testing of the blade and reported the results in the Structural Dynamics Technical Report "Flutter Analysis – Supersonic Natural Laminar Flow Test Blade for Mounting on the F-15B Test Aircraft". All margins are shown to be positive and Flight Operational Limits have been established.

Visual inspections of the SS-NLF Blade and centerline pylon will be performed per day-of-flight and inspection procedures. Mission Rules will be briefed at all SS-NLF Crew Briefs. Specific instructions to the research pilot will be to avoid over-flying populated areas and to adhere to the Flight Operational Limits (FOL). The control room will assist with the FOLs where on-board instrumentation is not available, ie yaw angle. Specific instructions to the chase pilot are to avoid flying directly behind or below the research aircraft.

Hazard Classification:

Before mitigating risk reduction actions: 1-D

After:

CAT 1: Hazard Severity remains CAT 1 due to personal injury that could occur if the SS-NLS Blade/pylon impacts the F-15B, the Chase Aircraft or persons on the ground.

PROB E: Extremely improbable.

Hazard Matrix

Preliminary Hazard Reports will be used by the F-15B project to assign each hazard a Hazard Matrix rating based on Severity and Probability. Experimenters should attempt to reduce experiment hazards to a Severity of III/IV and/or a Probability of E.

The F-15B Project will brief Dryden management of the planned testing and present the final Hazard Report prior to obtaining final flight approval.

The experimenters will be responsible for the operational safety of their equipment even though the equipment had passed the environmental testing. Dryden will maintain flight safety responsibility. This will include range/airspace scheduling, chase/photo coordination, F-15B aircraft, and general flight operations.

For more detailed information, project personnel can provide Hazard Management - DFRC DCP-S-002 or the System Safety Handbook – DHB-S-001 to assist with the hazard analysis and reporting process.

Go / No-Go Instrumentation, Mission Rules, and Operating Limitations

The F-15B Project will obtain input from the experimenter in the development of Go/No-Go Instrumentation, Mission Rules, and Operating Limitations. These listings and rules are defined prior to flight to ensure mission success and flight safety.

The Go/No-Go Instrumentation list is comprised of Mission Critical instrumentation and Flight Critical instrumentation. The Mission Critical instrumentation must be operational to proceed with the research mission. The Flight Critical instrumentation must be operational to guarantee flight safety. The loss of Mission Critical instrumentation results in the cancellation or termination of the research mission. The loss of Flight Critical instrumentation results in the cancellation or termination of the flight.

Mission Rules are generated to define the rules governing the conduct of the flight. The Mission Rules generally define such items as the chase aircraft requirements, acceptable weather conditions, approved flight maneuvers, control room staffing requirements, etc.

The aircraft flight operating limits are given in the Operating Limitations. This generally includes the maximum permissible Mach number, altitude, dynamic pressure, angle-of-attack, load factors, etc.

Control Room / Data Preparation

Control Room Displays

Control room displays are requested by the experimenter to provide real-time flight data. The displays may be simple strip charts and/or more complex graphical displays. The display requirements are provided by the experimenter and specified in the ORD. The project Test Information Engineer (TIE) develops the required displays and coordinates the display implementation and check-out in the control rooms with the experimenter.

Standard F-15B Project data displays are generally available for all test flights. These displays provide aircraft and flight fixture information as follows.

<u>Aircraft Information</u>

- Mach number
- altitude
- dynamic pressure
- angle-of-attack
- angle-of-sideslip

<u>Flight Test Fixture Information</u>

- local Mach number
- local angle-of-attack
- local angle-of-sideslip
- internal temperature
- linear acceleration
- local pressure data

Data Analysis Tools

The experimenter will work with the TIE to integrate any required real-time data analysis into the control room displays. Often, these analysis tools involve real - time Fortran (RTF) code that can be run in real-time and displayed in the control room.

The overwhelming majority of flight data obtained can be classified as time history data, that is, parameters as a function of time. The parameter values are usually sampled and recorded at regular time intervals. However, different parameters may be sampled at different rates. The time history flight data may be accessed through the NASA Dryden flight data access system (FDAS). The experimenter will be responsible for developing any additional data analysis tools that is required to post-process the flight data.

Procedures

Test Procedures

The experimenter shall provide documentation on the operating procedures, precautions and limitations of the experiment. These procedures shall include pre-flight, post-flight, and inspection procedures for ground operations. The experiment flight procedures will be put into flight card form so the data is gathered at the appropriate flight condition.

A Combined Systems Test (CST) will be performed as an end-to-end check of system functionality prior to flight. The CST will verify that the control room data displays are functioning properly and no electro-magnetic interference exists between the experiment and aircraft systems.

Final Flight Test Plan

The experimenter and the F-15B project will work together to formulate a flight test plan to safely accomplish the goals of the flight research. The final flight test plan must accommodate several different factors, including the experimenter's data collection needs, the aircraft's capabilities, airspace limitations, and flight safety concerns. The information in the final flight test plan is often derived from the flight test requirements contained in the ORD.

The final flight test plan should include details of the flight conditions and flight maneuvers desired. Typically, this may include specification of flight condition parameters such as Mach number, velocity, altitude, dynamic pressure, angle-of-attack, angle of sideslip. etc. The tolerance requirement for a flight condition parameter should be specified, e.g. test altitude of 24,000 feet, ±200 feet. Flight maneuvers may include flight test inputs such as doublets, pulses, raps, etc. in the pitch, roll, and/or yaw axes or other maneuvers such as climbs, descents, turns, sideslips, etc.

The flight test plan will be separated into one or more flights, as required to complete the plan. A flight profile diagram summarizes the requirements of each flight.

Flight Approval

The NASA Dryden flight approval process usually includes the completion of a Flight Readiness Review (FRR), an Airworthiness and Flight Safety Review Board (AFSRB), and Technical Briefings. Deviations from the basic flight approval process may be granted by the DFRC Chief Engineer. For example, smaller or less complex experiments with minimal risk are often granted FRR and AFSRB waivers, after review and approval by the DFRC Chief Engineer. Larger flight experiments with more inherent complexity and risk will most likely require more reviews within the flight approval process.

If more detailed information beyond the following summary on the flight approval process is required, project personnel can provide DFRC DHB-X-001.

Flight Readiness Review (FRR)

The FRR board is an independent review of the Project's readiness to proceed to flight. The FRR board is comprised of engineers and managers who are not affiliated with the Project. In general, the FRR board will have experts in the various flight test disciplines to review all aspects of the proposed flight test. The experimenter will assist the Project in preparing and presenting the briefings to the FRR board.

Airworthiness and Flight Safety Review Board (AFSRB)

The AFSRB is comprised of the Center Directorate Chiefs and the Center Chief Engineer, who acts as the board chairman. The FRR board chairman briefs the AFSRB on the Project's readiness to proceed to flight. After being briefed by the FRR chairman, the AFSRB makes its recommendation to the Center Director whether the Project should be allowed to proceed to flight.

Technical Briefing

The Technical Briefing (Tech Brief) describes the experiment to be flown and details the Project's readiness to fly the experiment. Research results from the flight tests completed to date are also presented. The Tech Brief is presented to Dryden Center management for approval to fly a block of flights that constitute an identifiable phase of the flight test program. The Tech Brief will normally contain the following:

Tech Brief (example outline)

Objectives
Review of Past Flights
Experiment Overview
    General Description
    Hardware Flight Qualification
Configuration Changes
    Aircraft Configuration Changes
    Instrumentation Configuration Changes
Flight Test Plan
Control Room Operations
Go / No-Go Instrumentation
Mission Rules / Flight Limitations
Hazards / Accepted Risks
Flight Request

If flight operations and engineering flight results are nominal during the Tech Briefed flight phase, no further briefings are necessary. If problems, anomalies, unusual results, or hazardous conditions arise, or additional required ground tests are accomplished, then an additional "Mini-Tech Brief" between flights may be required to address these issues. The "Mini-Tech" is particularly required if there is a potential safety of flight impact or if a major in-flight finding or discrepancy has occured. The format and content of the "Mini-Tech Brief" is similar to the Tech Brief, however, judgment should be used to focus on the specific concern(s) and not repeat irrelevant information from the most recent Tech Brief.

The Experimenter contributes to most of the Tech Brief topics listed above. Typically, the Experimenter presents the information contained within the Experiment Overview section.

Flight Test Documentation

Flight Test Report

A Flight Test Report is written after each flight to document the flight and the flight results. The Flight Test Report may include the following:

Flight Summary Sheet
Narrative Summary
Aircrew Report
Project Chief Engineer/Principle Investigator Report
Operations Engineer Report
Project Manager Report
Flight Profile
Flight Cards

Flight Test Summary

At the conclusion of each experiment, the experimenter is asked to provide the F-15B Project with a summary of the experiment. Typically, this summary is a 3 - 5 page PowerPoint presentation that contains the experiment objectives, general description, and flight test results.

Technical Report (s)

Technical reports are written as appropriate by the experimenter and the F-15B Project. These reports may include, but are not limited to, conference papers, journal articles, NASA Technical Memorandums, etc. Collaborative reports between the experimenter and appropriate F-15B Project engineers are highly encouraged.